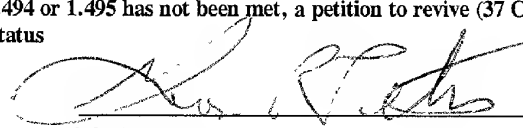


TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 0162/00564	
		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/601515	
INTERNATIONAL APPLICATION NO. PCT/JP99/07180	INTERNATIONAL FILING DATE December 21, 1999	PRIORITY DATE CLAIMED December 24, 1998	
TITLE OF INVENTION ACOUSTIC EFFECT APPARATUS AND METHOD AND PROGRAM RECORDED MEDIUM THEREFOR			
APPLICANT(S) FOR DO/EO/US Haruhiko Motohashi Yasuhiko Mori Mikio Nagashima			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
<p>1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371</p> <p>2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. § 371.</p> <p>3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).</p> <p>4. <input type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.</p> <p>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))</p> <p style="margin-left: 20px;">a. <input checked="" type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau).</p> <p style="margin-left: 20px;">b. <input type="checkbox"/> has been transmitted by the International Bureau.</p> <p style="margin-left: 20px;">c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</p> <p>6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)).</p> <p>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))</p> <p style="margin-left: 20px;">a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau).</p> <p style="margin-left: 20px;">b. <input type="checkbox"/> have been transmitted by the International Bureau.</p> <p style="margin-left: 20px;">c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</p> <p style="margin-left: 20px;">d. <input type="checkbox"/> have not been made and will not be made.</p> <p>8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</p> <p>9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> A translation of the Annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p>			
Items 11. to 16. below concern other document(s) or information included:			
<p>11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</p> <p>12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</p> <p>13. <input type="checkbox"/> A FIRST preliminary amendment.</p> <p style="margin-left: 20px;"><input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.</p> <p>14. <input type="checkbox"/> A substitute specification.</p> <p>15. <input type="checkbox"/> A change of power of attorney and/or address letter</p> <p>16. <input checked="" type="checkbox"/> Other items or information:</p>			
Verification of Translation; International Search Report; translation of PCT request; Verified statement claiming small entity status			

428 Rec'd PCT/PTO 02 AUG 2000

U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/601515		INTERNATIONAL APPLICATION NO PCT/JP99/07180		ATTORNEY'S DOCKET NUMBER 0162/00564	
<input checked="" type="checkbox"/> The following fees are submitted: Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO.....\$840.00 International preliminary examination fee paid to USPTO (37 CFR 1.482)\$670.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).....\$760.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....\$970.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4).....\$96.00				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT = \$840.00					
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	95 - 20 =	75	X \$18.00	\$1,350.00	
Independent Claims	5 - 3 =	2	X \$78.00	\$156.00	
Multiple dependent claim(s)(if applicable)			+ \$260.00	\$260.00	
TOTAL OF ABOVE CALCULATIONS =				\$2,606.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28)				\$1,303.00	
SUBTOTAL =				\$1,303.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$	
TOTAL NATIONAL FEE =				\$1,303.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +				\$40.00	
TOTAL FEES ENCLOSED =				\$1,343.00	
				Amount to be: refunded \$	
				charged \$	
a. <input checked="" type="checkbox"/> A check in the amount of \$1,343.00 to cover the above fees is enclosed.					
b. <input type="checkbox"/> Please charge my Deposit Account No. <u>22-0185</u> in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed.					
c. <input checked="" type="checkbox"/> The Director is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>22-0185</u> . A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status					
SEND ALL CORRESPONDENCE TO: Pollock, Vande Sande & Amernick, R.L.L.P. 1990 M Street, N.W., Suite 800 Washington, DC 20036-3425					
				SIGNATURE 	
				NAME George R. Pettit	
				REGISTRATION NUMBER 27,369	

09601515-0000

11F05445

SMALL ENTITY DECLARATION

APPLICANT OR PATENTEE KORG INCORPORATED

SERIAL NO. _____ ☐ PATENT NO. _____ ATTORNEY'S DOCKET NO. _____

(Check one of blocks 1 or 2.)

1. ☐ FILED OR ISSUED _____

2. ☒ SUBMITTED HEREWITH _____

FOR "ACOUSTIC EFFECT APPARATUS AND METHOD AND PROGRAM RECORDED MEDIUM THEREFOR" (Insert Title)

I(we) hereby declare that I(we) am(are) entitled to the benefit of small entity status with respect to the above-identified application or patent for purposes of paying reduced fees under 35 USC 41(a) & (b) to the U.S. Patent and Trademark Office.

☐ A. INDEPENDENT INVENTOR

I(we) qualify as (an) independent inventor(s) as defined in 37 CFR 1.9(c).

☐ B. INDIVIDUAL NON-INVENTOR

I would qualify as an independent inventor as defined in 37 CFR 1.9(c) if I had made the invention.

☒ C. SMALL BUSINESS CONCERN

I am ☐ THE OWNER ☒ AN OFFICIAL of the small business concern identified below and am empowered to act on behalf of the concern. The concern qualifies under 37 CFR 1.9(d) and 13 CFR 121.3-18. Rights under contract or law have been conveyed to and remain with the concern and are exclusive unless a checkmark is placed here ☐. All other rights belong to small entities as defined in 37 CFR 1.9.

☐ D. NON-PROFIT ORGANIZATION

I am an official empowered to act on behalf of the non-profit organization identified below. The organization qualifies under 37 CFR 1.9(e), sub-section: ☐ (1) ☐ (2) ☐ (3) ☐ (4). Rights under contract or law have been conveyed to and remain with the organization and are exclusive unless a checkmark is placed here ☐. All other rights belong to small entities as defined in 37 CFR 1.9.

I(we) acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I(we) declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

A. INDEPENDENT INVENTOR(S) B. INDIVIDUAL NON-INVENTOR(S)

Name	Signature	Date
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Name	Signature	Date
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Name	Signature	Date
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C. BUSINESS CONCERN D. NON-PROFIT ORGANIZATION 15-12, Shimotakaido 1-chome, Suginami-ku, Tokyo 168-0073, Japan

Name of Concern or Organization	Address
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By <u>Sadao Fukushima</u> Name of Person Signing	<u>Sadao Fukushima</u> Signature
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<u>President</u> Title	<u>July 19, 2000</u> Date
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13/P245

-1-

ACOUSTIC EFFECT APPARATUS AND METHOD
AND PROGRAM RECORDED MEDIUM THEREFOR

TECHNICAL FIELD

5 The invention relates to an apparatus and a method for imparting an acoustical effect by boosting a bass region of an audio signal such as a musical tone signal, and a program recorded medium used therefor.

BACKGROUND ART

Some people desire to enjoy a physical sensation of a music in
10 addition to listening to the music through the ear. A physical sensation of the music may be obtained by boosting bass tones to a higher loudness level. In the conventional practice of boosting bass tones, an equalizer is used to boost the bass region of an audio signal, and the boosted audio signal is
15 amplified by a high capacity output amplifier, an amplified output signal of which is used to drive a gigantic woofer (loudspeaker used devotedly for the bass region). However, this approach fails to yield the intended effect unless the boosting of the bass tones takes place to a great extent. If it is attempted to achieve a similar effect with a low capacity output amplifier and a small size loudspeaker, there results a distortion of sounds.

20 It is recognized that auditory sensation of a man is susceptible to a tendency that he feels bass tones boosted when listening to harmonics containing a lot of overtones of bass components. There is a proposal that exploits this tendency to achieve an apparent boosting of bass tones by feeding bass components of an input audio signal to a nonlinear circuit to
25 produce overtones of bass components in the input audio signal, which are then added to the input audio signal.

To give an example, Japanese Laid-Open Patent Application No.

328,481/1993 proposes a technique illustrated in Fig. 1. Specifically, stereophonic left-channel and right-channel signals from input terminals 11L and 11R are passed through low pass filters 12L and 12R, respectively, having a cut-off frequency of 100Hz to pick out bass components equal to or less
5 than 100Hz, which are then subject to full wave rectification in a full wave rectifier circuit 13. An output signal from the full wave rectifier 13 is then passed through a bandpass filter 14 having a pass band of 100~200Hz. In other words, double overtone signals of bass components produced by the full wave rectifier circuit 13 may be obtained from the bandpass filter 14 and
10 added to the left-channel and right-channel signals from the input terminals 11L and 11R to be delivered to output terminals 15L and 15R.

The prior art shown in Fig. 1 picks out bass components through the low pass filters 12L, 12R. These low pass filters 12L, 12R have a cut-off frequency of 100Hz, and have an increased time constant, which causes the
15 output signal from the bandpass filter 14 to be synthesized in a considerably lagging relationship with respect to the input signals from the input terminals 11L, 11R. This means that signals in the input audio signal which represent vocals and tones from alto or middle frequency range musical instruments such as tenor saxophone as well as tones from high pitch or frequency range
20 musical instruments such as a violin and a flute would be displaced in time with respect to signals representing tones from bass instruments such as a base and a bass drum, presenting a strange sensation for a concurrent rendition of these musical instruments.

Also proposed in Japanese Laid-Open Patent Application No.
25 186,008/1989 is a technique illustrated in Fig. 2. An input audio signal from an input terminal 11 is fed to a low pass filter 12 having a cut-off frequency on the order of 100Hz, and bass components from the low pass filter 12 are

amplified by a power amplifier 16 before being input to a nonlinear circuit 17. The nonlinear circuit 17 comprises two diodes in anti-parallel connection which clip the positive and the negative side of the input signal amplitude, whereby the input signal waveform is distorted, producing harmonics components of the input signal or overtone signals. The overtones thus produced are added to the input audio signal from the input terminal 11 in a summer 18 to be delivered to an output terminal 15.

Again in this prior art, the low pass filter having a cut-off frequency on the order of 100Hz is used, and thus there remains the problem of time misalignment between bass components and higher pitch components in the similar manner as occurs with the technique shown in Fig. 1. Furthermore, if a base tone containing a component having a fundamental frequency of 110Hz is concurrently input with a bass drum tone containing a component having a fundamental frequency of 100Hz, the nonlinear circuit 17 would produce components representing both sum and difference between the both input signals, or 10Hz component and 210Hz component, resulting in boosting unwanted bass tones and producing sounds which are unmusical and grating.

In addition, proposed in Japanese Laid-Open Patent Application No. 295,178/1994 is a technique illustrated in Fig. 3. The technique is employed in a sound source unit for an electronic musical instrument. Accordingly, musical tone waveform data from an input terminal 1 comprises sinusoidal wave data having a fundamental frequency such as a sound produced by the oscillation of a single string, for example, and sinusoidal wave data for overtone frequencies thereof, and thus is not data which represent waveforms of musical tones from a plurality of musical instruments. This musical tone waveform data is delayed by one clock period (a sampling period of the

musical tone waveform data) in an interruption circuit 21a in a differential circuit 21. The delayed data is subtracted from non-delayed data in a subtractor 21b, and a result of subtraction is delivered as a differential data to be input to a non-linear conversion table 22 where the differential data is
5 subject to a non-linear conversion by the non-linear conversion table 22. The converted data is summed with multiplication output data from a multiplier 23a in an additive circuit 23. A result of summation is delivered as musical tone data having added bass tones to an output terminal 15. The output musical tone data is also delayed by one clock period by a delay circuit
10 23c to be input to the multiplier 23a, which multiplies the input data by a diversion preventive coefficient a.

In this manner, higher pitch components are boosted in the differential circuit 21 so that the non-linear conversion by the non-linear conversion table 22 allows musical tones, which are overtones based on the higher pitch
15 components, to be produced, while bass components are boosted in the additive circuit 23, with the distortion of overtones and the like which are based on the higher pitch components being boosted to a greater degree than the distortion of overtones and the like which are based on the bass components while allowing the bass components to be also boosted.
20 Descriptions are given that the differential circuit 21 exhibits a response similar to a high pass filter with respect to input waveform data, that bass components similar to waveform data which is input appear in the additive circuit 23, and that a musical tone waveform signal is obtained which includes a distortion of overtones and the like resulting from the higher pitch
25 components.

In this prior art, as many as six versions of input-output response of the non-linear function which the non-linear conversion table 22 yields are

indicated in Fig. 5 of the above cited Application. These responses have a point symmetry as illustrated in Fig. 4 with respect to an input reference point, namely, a point of intersection P_0 between an input axis and an output axis, as illustrated. As a consequence, overtones which are produced as a result of the non-linear conversion by the non-linear conversion table 22 include more of odd-numbered harmonics (overtones) than even-numbered harmonics (overtones), and it is noted that such a musical tone having an abundance of odd-numbered overtones disadvantageously leads to an indistinct and vacant timbre. As described, the higher pitch components of the input musical tone data is boosted in the differential circuit 21 before it is fed to the non-linear conversion table 22. In other words, all of higher pitch components in the input musical tone data are boosted before being fed to the non-linear conversion table 22. Hence, where the input data comprises an output signal from a CD (compact disc) player or a rendition output signal from an electronic musical instrument, not only musical tone data from a bass musical instrument such as a base or a bass drum, but data for tones from a variety of musical instruments such as data for vocals and tones from alto musical instrument such as saxophone as well as data for musical tones from alto and higher pitch musical instruments such as violin, flute and the like are also included ; or more specifically, what is input to the table 22 has an abundance of data representing musical tones having components equal to or higher than 400Hz. Accordingly, data for musical tones in the alto and higher pitch range, which are unnecessary for boosting musical tone data for bass tones, are also boosted and subjected to the non-linear conversion by the non-linear conversion table 22, causing higher pitch data to be produced which are distorted in an unnecessary manner. This, in addition to degrading the boosting of bass tones in a relative sense, results in a cross modulation when

the plurality of varieties of alto and higher pitch musical tone data are input to the non-linear conversion table, producing components corresponding to differences and sums of frequencies among the plurality of alto and higher pitch musical tone data, that is, components which are not originally
5 contained in the musical tone signal, and thus disadvantageously producing acoustic abnormalities in the auditory sensation.

It is an object of the present invention to provide an apparatus and a method for acoustic effect which is capable of producing overtones of fundamental tones of bass musical instruments such as a base, a bass drum
10 and the like and boosting bass tones while maintaining a time concurrency between bass components and alto and/or higher pitch components so as to yield brilliant and clearly intonated sounds.

It is another object of the invention to provide an apparatus and a method for acoustic effect which is capable of producing overtones of
15 fundamental tones of bass musical instruments such as a base, a bass drum and the like and boosting bass tones while maintaining a time concurrency between bass components and alto and/or higher pitch components without producing components which are not originally present in the musical tone signal to cause acoustic abnormalities in the auditory sensation.

20 It is to be understood that what is generically referred to herein as a bass musical instrument is one which produces a fundamental tone equal to or below 200Hz. Accordingly, while it is possible to produce a fundamental tone of 300Hz with the base, the latter is not included in the bass musical instrument when it is used to produce a fundamental tone of such a higher
25 pitch.

DISCLOSURE OF THE INVENTION

In one form of the invention, components corresponding to double or

higher overtones of a bass musical instrument such as a base, a bass drum or the like are picked out from an input audio signal by filter means, and distortion applying means applies a non-linear distortion which is unsymmetrical with respect to the center of an amplitude to the components which correspond to double or higher overtones.

In another form of the invention, components corresponding to double overtone regions of a bass musical instrument such as a base or a bass drum are picked out from an input audio signal by filter means, and distortion applying means applies a non-linear distortion to the double overtone region components which are picked out.

In either form, it is preferred to pick out components corresponding to fundamental tones of each bass instrument while reducing a level thereof also.

In either form, it is preferred that higher pitch components be removed from an output signal from the distortion applying means by means of a low pass filter means.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing one example of a conventional bass boosting circuit;

Fig. 2 is a block diagram showing another example of a conventional bass boosting circuit;

Fig. 3 is a block diagram showing a musical tone processor of a sound source unit of a conventional electronic musical instrument;

Fig. 4 diagrammatically illustrates several examples of a conversion response of a non-linear conversion table 22 shown in Fig. 3;

Fig. 5 is a block diagram showing an embodiment of the invention;

Fig. 6 diagrammatically illustrates an example of input-output response of distortion applying means 34 shown in Fig. 5;

Fig. 7 is a circuit diagram of an example in which the arrangement shown in Fig. 5 is formed with an analog circuit;

Fig. 8 diagrammatically illustrates an amplitude-frequency response of filter means 31 shown in Fig. 7;

5 Fig. 9 is a circuit diagram showing a specific example of distortion applying means 34 shown in Fig. 5;

Fig. 10 diagrammatically illustrates a collector current responses of a transistor 44 shown in Fig. 9;

10 Fig. 11 diagrammatically illustrates an input-output response of a distortion applying circuit shown in Fig. 9;

Fig. 12 diagrammatically illustrates an amplitude-frequency response of a low pass filter 37 shown in Fig. 7;

Fig. 13 is a circuit diagram showing an example in which filter means 31 is formed with a bandpass filter;

15 Fig. 14 diagrammatically illustrates an exemplary amplitude-frequency response of the bandpass filter shown in Fig. 13;

Fig. 15 diagrammatically illustrates an exemplary response of a high pass filter 32 having a shoulder peak in its cut-off response;

20 Fig. 16 diagrammatically illustrates an exemplary response of a narrow-bandpass filter acting as filter means 31 to pick out a double overtone component of a desired bass tone;

Fig. 17 is a block diagram showing an exemplary arrangement in which the present invention is embodied by the execution of a program by CPU or DSP; and

25 Fig. 18 is a flow chart of an exemplary procedure of the method according to the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

Fig. 5 shows an embodiment of the invention. An audio signal such as an output signal from a CD (compact disc) player (which may be a digital output signal), a rendition output signal from an electronic musical instrument, a rendition output signal from an electrical musical instrument, an output
5 signal from a microphone which receives the sound of a music being played in an auditorium, a digital signal which is decoded from musical data transmitted by an electronic distribution is input to an input terminal 11.

Filter means 31 picks out the signals corresponding to double or higher overtones of a bass musical instrument such as a base or a bass drum
10 from the input audio signal from the input terminal 11. In the present instance, the filter means 31 only comprises a high pass filter (HPF) 32. The high pass filter 32 has a cut-off frequency F_{ch} which depends on the variety of a musical instrument, for which the bass tones are to be boosted, and which lie in a range of 50~300Hz, but which may be on the order of 200Hz so as to
15 be generally applicable to any bass musical instrument. The high pass filter 32 has a cut-off response which is chosen so that components corresponding to fundamental tones of the bass musical instrument are reduced in their levels, but can not be completely cut off so as to be delivered from the high pass filter 32. The cut-off response may be preferably on the order of 12dB/OCT,
20 for example. Specifically, assuming that a bass tone to be boosted has a fundamental tone of 100Hz while the high pass filter 32 has a cut-off frequency of 200Hz, the fundamental component of 100Hz appears in the output signal from the high pass filter 32 with a level reduction by a factor of 4.

25 This embodiment is designed so as to pick out components corresponding to double overtone regions of a bass musical instrument from the input audio signal by means of the filter means 31, and a low pass filter

(LPF) 33 is connected in series with the high pass filter 32. The cut-off frequency F_{ch} of the high pass filter 32 and the cut-off frequency F_{cl} ($F_{cl} > F_{ch}$) of the low pass filter 33 are chosen so that a band between the cut-off frequencies F_{ch} and F_{cl} substantially coincides with the double overtone regions of the bass musical instrument. The cut-off frequency F_{cl} depends on the variety of a musical instrument for which the bass tones are to be boosted, and is chosen in a range of 200~450Hz. However, when F_{cl} equal to or higher than 450Hz is chosen, when a non-linear distortion is applied to components which are picked out by the filter means 31, a cross modulation causes acoustic abnormalities to be produced resulting in boosting undesirable, relatively higher pitch tones and thus losing the bass tone boosting effect. To be suitable to any bass musical instrument, it is preferable that the cut-off frequency F_{cl} be on the order of 400Hz. In order to prevent such acoustic abnormalities from occurring, it is desirable that the low pass filter 33 has a steep cut-off response, which should be at least equal to -12dB/OCT, preferably -24dB/OCT or even steeper.

When picking out components corresponding to double overtone regions, it is preferred for the filter means 31 to be adequate to any bass musical instrument that it has a cut-off frequency F_{ch} on the order of 200Hz and a cut-off response on the order of +12dB/OCT on the bass side and a cut-off frequency F_{cl} on the order of 400Hz and a cut-off response of -24dB/OCT or a steeper bandpass response on the higher pitch side.

Components corresponding to double overtone regions of the bass musical instrument contained in the input audio signal which are picked out by the filter means 31 are fed to distortion applying means 34 where a non-linear distortion is applied thereto. The distortion applying means 34 has a non-linear input-output response, and in particular a non-linear response

which has no point symmetry with respect to the center of an amplitude of the input signal is desirable. For example, as illustrated in Fig. 6, it is desirable to have an S-shaped curve 36 as contrasted to a rectilinear line 35 and which has a warped configuration so that the S-shape does not exhibit a point

5 symmetry with respect to reference point P_0 of the input axis, which is a point of intersection (0,0) between the input axis and the output axis as shown. Preferably, a non-linear characteristic curve 36 is located on the output axis side of the rectilinear line disposed at an angle of 45° with respect to the input axis and passing through the reference point P_0 , which represents a

10 linear characteristic line providing equal values between an input value and an output value, so that it provides a greater output for a small input, thus exhibiting a gain greater than 1 while the gain is reduced and the output approaches a saturation as the input increases. It should be noted that the reference point P_0 is not limited to a point where the input value is 0 and the

15 output value is equal to 0, but considering the application of a bias, the center of an amplitude of the input signal is chosen as the reference point.

The distortion applying means 34 applies a distortion to the input components corresponding to the double overtone regions, thus producing their harmonics (overtones). The distorted components corresponding to the

20 double overtone regions may be fed to a low pass filter (LPF) 37 as required to remove unnecessary higher pitch components which may be harmful to the auditory sensation. Alternatively, a suitable frequency response may be given to the produced harmonics (overtone) components. The low pass filter 37 may have a cut-off frequency on the order of 200Hz and a cut-off response

25 of -12dB/OCT .

In this manner, a signal containing overtones which correspond to the components corresponding to the double overtone regions is obtained from

the low pass filter 37, and is summed with the input audio signal from the input terminal 11 in a summer 18 to be delivered to an output terminal 15.

The audio signal delivered from the output terminal 15 has an abundance of overtones and thus includes an apparent boosting of bass tones.

5 Specifically, a musical tone signal which is produced as the musical instrument is attacked on and which has a higher level for overtones will be subject to the saturation region of the S-shaped response (Fig. 6) of the distortion applying means 34, whereby they are strongly compressed to produce more overtones, thus boosting a beat sensation and an impact
10 sensation. If the level is slightly reduced subsequent to the attack, the output level does not decline immediately because a corresponding central region of the S-shaped response has a high gain. Thus, overtones of a musical tone signal which eminently represent the power of expression and features of a base or a bass drum used as a musical instrument are more positively
15 pronounced upon attack, and then if the level of the original tone is reduced, the levels of the overtones which the musical tone signal originally contains are raised by the gain which is obtained in the central region of the S-shaped response to boost changes in the timbre of the base or the bass drum, combined with the production of overtones anew which is achieved by the
20 non-linearity in the central region of the S-shaped response even though such non-linearity is not so remarkable as noted in the saturation region of the S-shaped response. Thus, the features of the S-shaped response are effective, not only upon the attack of the base or the bass drum, but over the entire musical tones, to extract and boost the abundant music-expressing elements of
25 the base or the bass drum which are masked and embedded therein, namely, the sense of the bass drum driving the air with sound pressure, delicate expressions upon attack and the slight reverberation of bass tones of the base,

thereby producing new overtones in a more exaggerated manner to yield a sense of impact and a dynamic sense. When the S-shape response is chosen to avoid the point symmetry (or to produce asymmetry between the positive and the negative side) as shown in Fig. 6, odd-numbered overtones can be
5 diminished while even-numbered overtones can be augmented to allow tones of a more abundance and a less impurity in the musical sense to be obtained.

Furthermore, by picking out components corresponding to double overtone regions by means of the filter means 31, a plurality of varieties of musical tone signals from higher pitch musical instruments which are of a
10 higher pitch than such region can not be input simultaneously into the distortion applying means 34. In other words, the likelihood that overtones of musical tone signals from these higher pitch musical instruments are produced to cause a cross modulation is eliminated, thus eliminating the likelihood that acoustic abnormalities which can not be found in the music
15 and which are grating may be produced. Because a low pass filter having a larger time constant which may be exemplified by a cut-off frequency of 100Hz is not used, a time concurrency between higher pitch components and the distorted bass and alto components in the input audio signal can be secured in the output signal.

20 A specific example of forming the acoustic effect apparatus shown in Fig. 5 with an analog circuit is shown in Fig. 7. An input audio signal from an input terminal 11 passes through a d.c. cut-off capacitor 41 and thence through a buffer circuit 42 to be fed to a high pass filter 32, which comprises capacitive elements, resistor elements and an operational amplifier to act as a
25 second order active filter. An output signal from the high pass filter 32 is fed to a low pass filter 33, which comprises a series circuit of second order active filters 32a and 33b, each comprising resistor elements, capacitive elements

and an operational amplifier, and which is thus formed as a fourth order active filter having a steep cut-off response.

A total amplitude-frequency response of the high pass filter 32 and the low pass filter 33 becomes as shown in Fig. 8. It will be seen from this
5 Figure that the high pass filter 32 has a cut-off frequency of about 200Hz and a cut-off response substantially equal to 12dB/OCT while the low pass filter 33 has a cut-off frequency of about 450Hz and a cut-off response substantially equal to -24dB/OCT. Thus, the both filters 32 and 33 constitute together a bandpass filter having a pass band of 200Hz~450Hz and in which the cut-off
10 on the bass side takes place gently with +12dB/OCT while the cut-off on the higher pitch side takes place steeply at -24dB/OCT.

An output signal from the low pass filter 33 is passed through a d.c. cut-off capacitor 43 to distortion applying means 34. The distortion
applying means 34 utilizes the non-linearity in a small V_{CE} region of a
15 collector current I_c -collector-emitter voltage V_{CE} response of a transistor 44. The distortion applying means 34 is described, for example, in Japanese Laid Open Patent Application Number 76,753/1996. Briefly describing this, this distortion applying circuit comprises a transistor 44 and an operational
amplifier 45 as shown in Fig. 9. In this example, an NPN transistor is used
20 for the transistor 44, with the collector of the transistor 44 connected to a signal source 46, and the emitter of the transistor 44 connected to an input point A of the operational amplifier 45. A buffer amplifier 47 is connected to the output side of the operational amplifier 45, and an output from the
buffer amplifier 47 is taken out through a d.c. blocking capacitor 48 to an
25 output terminal 49. A bias voltage V_B of a positive polarity is supplied from a power source 52 to the base of the transistor 44 through a current adjusting resistor 51. The input point A of the operational amplifier 45 represents an

inverting input terminal, to which a feedback signal is negatively fed back from the output through a feedback resistor 53.

It is assumed that a signal source 46 delivers a signal of minimal amplitude which does not include a direct current voltage. The voltage at the input point A of the operational amplifier 45 is maintained at the same potential as the common potential by the negative feedback operation. As a consequence, the voltage of the signal which is delivered from the signal source 46 is applied alone across the collector-emitter of the transistor 44. Under this condition, the transistor 44 operates in a non-linear region B of the collector current I_c -collector-emitter voltage V_{CE} response in the vicinity of point zero as shown in Fig. 10.

Since the signal delivered from the signal force 46 has a level of a minimal value in the non-linear region B, it follows that the transistor 44 feeds an emitter current (which is substantially equal to a collector current) to the input point A in accordance with the amplitude of the signal applied from the signal source 46 about the zero point of the collector current response.

When the resistance R_f of the feedback resistor 53 is adjusted such that the level V_{OUT} of an input signal delivered to the output signal 49 is equal to the level V_{IN} of the input signal such that $V_{OUT} = V_{IN}$ as the resistance of the current adjusting resistor 51 is adjusted to change the base current I_B from I_{B1} to I_{B5} ($I_{B1} > I_{B2} > I_{B3} > I_{B4} > I_{B5}$), it will be seen that when the base current I_B is sufficiently high as indicated by I_{B1} , there results a nearly linear response as indicated in Fig. 11, but as the base current I_B is gradually decreased, the collector current tends to exhibit a constant current response in the positive region, thus enhancing the distortion.

Because the amplification factor H_{fe} is small in the negative region, a change in the collector current response in the negative region is small.

When the response which changes between the positive and the negative region is considered as a non-linear response, it can be said that a negative distortion response is relatively smooth while the distortion in the positive side is sharp, representing a response having an abundance of overtones.

5 When there is a difference between the positive and the negative response, it is possible to produce many even-numbered overtones. Where the distortion is symmetrical in both the positive and the negative side, it is possible to produce odd-numbered overtones. Accordingly, by adjusting the base current I_B , the manner of distortion occurring can be controlled, allowing
10 the distortion to be adjusted to achieve a desired timbre.

 In Fig. 7, a low pass filter 37 comprises an operational amplifier 55, resistor elements and capacitive elements, and the emitter of the transistor 44 in the distortion applying means 34 is connected to an inverting input terminal of the operational amplifier 55 which is arranged on the input side of the filter,
15 and the operational amplifier 55 also serves as an operational amplifier 45 shown in Fig. 9. The amplitude-frequency response of the low pass filter 37 is shown by a curve 56 in Fig. 12. It will be seen from this Figure that the low pass filter 37 has a cut-off frequency of about 200Hz and a cut-off response substantially equal to -12dB/OCT . Since frequency components in
20 the harmonic (overtone) components produced by the distortion applying means 34 which are effectively acting in boosting the bass tones are in a range of 200Hz \sim 1kHz, it will be seen that this band is located adjacent to the beginning of the attenuation for the higher pitch cut-off in the frequency response, and thus there is provided an arrangement such that components in
25 a range of 200Hz \sim 1kHz undergo a greater reduction in their levels as the frequency increases, thus preventing the higher pitch regions in these components from being excessively boosted. In other words, the low pass

filter 37 provides a balance between the bass components and the higher pitch components.

An output signal from the low pass filter 37 and an output signal from the buffer circuit 42 are summed together in a summer 18 which comprises an operational amplifier 57, and a summed output signal is delivered to an output terminal 15 through a direct current cut-off capacitor 58. While an input signal to the summer 18 is connected to the inverting input through a resistor in the circuit diagram, it should be understood that it may be connected to the non-inverting input. A capacitor which is connected across the operational amplifier 57 to provide a negative feedback has a capacitance which is as small as 100pF and is used to eliminate noises, and does not function substantially as a low pass filter. Incidentally, a total amplitude-frequency response of the low pass filter 37 and the summer 18 is shown by a curve 59 in Fig. 12. The operational amplifier 57 also serves as a buffer amplifier 47 shown in Fig. 9. Numerals entered neighboring individual resistor elements in Fig. 7 indicate their resistances while numerals entered neighboring individual capacitors indicate their capacitances.

In the specific example shown in Fig. 7, the filter means 31 provide a level reduction by a factor of 4 for a fundamental tone component of 100Hz, for example, while no level reduction occurs for components corresponding to its overtones of 200Hz, 300Hz and 400Hz when they are input to the distortion applying means 34, where a distortion is applied to an overtone component of 200Hz which has a relatively high level, whereby overtone components of 400Hz, 600Hz and 800Hz are produced. It is to be noted that all of these overtone components produced represent even-numbered overtones of the fundamental tone component of 100Hz, allowing a tone to be obtained which has an abundance and which is free from impurity. In

particular, because the filter means 31 interrupts the audio signal which is located on the order of 400Hz or above, a higher pitch musical tone component can not be input to the distortion applying means 34 if a musical tone signal from a higher pitch musical instrument is input to the input terminal 11, thus avoiding the occurrence of a cross modulation thereof to cause the occurrence of acoustic abnormalities. Assuming that the non-linear response of the distortion applying means 34 has no point symmetry with respect to the center of the input amplitude as indicated in Fig. 6, many even-numbered overtone components of the 200Hz input overtone component (400Hz, 800Hz, 1200Hz...) are produced while odd-numbered overtone components are reduced, thus providing a tone having an abundance and freedom from impurity for the input 200Hz overtone.

Even though components having frequencies of 100Hz and 500Hz which represent the difference and the sum between the 200Hz component and the 300Hz component contained in the input overtone components as well as components having frequencies of 100Hz and 700Hz which represent the difference and the sum between the 300Hz overtone component and the 400Hz overtone component contained in the input overtone components, or odd-numbered overtone components for the fundamental tone component, are also produced by the non-linear response of the distortion applying means 34, it will be seen that the number of these is reduced, and in addition, the overtone components which are input are considerably reduced in their levels as compared with the fundamental tone component which does not undergo a level reduction, and accordingly, the odd-numbered overtone components which are generated have reduced levels, and can not have any significant influence upon the tones in the output audio signal. If musical tone signals from different varieties of bass musical instruments are simultaneously input,

the filter means 31 pick out components corresponding to their overtone regions and allow them to be input to the distortion applying means 34. Even though components representing the differences between and the sums of the components corresponding to overtone regions of different varieties of musical instruments, or tone components which are not inherent in the respective musical instruments are produced, there is little influence of them upon the tones in the output audio signal as compared with the components representing the differences between and the sums of the fundamental components of different varieties of musical instruments inasmuch as the components corresponding to the overtone regions have levels which are considerably reduced in comparison to the fundamental components.

The fundamental tone components (100Hz) which has its level reduced is input to the distortion applying means 34 where its overtones are produced without accompanying the problems of the prior art to any significant degree, thus achieving a boosting of the bass tones which has been intended in the prior art.

When the input audio signal contains a vocal or a musical tone signal from alto and/or bass musical instrument such as a tenor saxophone, such signal can not cause many overtone components to be produced because of its reduced level if the signal from the alto and/or bass musical instrument is also input to the distortion applying means. Rather, an increased gain in the central region of the S-shape response allows tone components from the alto and/or bass musical instrument to be boosted, providing an additional effect that the vocal or the musical tone from the tenor saxophone can be musically accentuated.

Denoting the resistances of resistor elements 61 and 62 by R1 and R2 and the capacitances of capacitors 63 and 64 contained in the high pass filter

32 by C1 and C2, the high pass filter 32 has a cut-off frequency which is defined by $F_{ch}=1/(2\pi\sqrt{R1 \cdot R2 \cdot C1 \cdot C2})$. Accordingly, the cut-off frequency Fch can be changed to a desired value by choosing these constants R1, R2, C1 and C2. In a similar manner, denoting the resistances of resistor elements 65 and 66 in the low pass filter 33a of the low pass filter 33 by R3 and R4 and the capacitances of capacitors 67 and 68 by C3 and C4, the cut-off frequency is defined by $1/(2\pi\sqrt{R1 \cdot R2 \cdot C1 \cdot C2})$. Accordingly, the cut-off frequency can be changed to a desired value by choosing these constants R3, R4, C3 and C4 and by similarly choosing the constants of corresponding elements in the filter 33b. It is also possible to allow a user to set up the cut-off frequency of the high pass filter 32 and the cut-off frequency of the low pass filter 33 by providing an arrangement in which the resistances of resistor elements in the filters 32 and 33 can be changed as required.

The cut-off frequency and/or the cut-off response of the low pass filter 37 may be chosen to be adjustable so that they may be adjusted to the preference of a user. The low pass filter 37 may be omitted by choosing the non-linear response of the distortion applying means 34 so that the suppression response for the higher pitch components and/or the cut-off frequency may be chosen depending on the non-linear response or in accordance with the occurrence of harmonics (overtones) so that the distortion applying means 34 may produce desired harmonics (overtones) at desired levels. To provide such distortion applying means 34, desired non-linear responses may be entered in storage means which store output values in relation to an address corresponding to an input value, for example, and the storage means may be read in terms of the address which is defined by the level of the input audio signal.

In the above description, the filter means 31 comprises the high pass

filter 32 and the low pass filter 33, but may comprise a single bandpass filter. An example of such bandpass filter is shown in Fig. 13. Specifically, an input terminal is connected to an input terminal of an operational amplifier 73 through a series circuit of resistor 71-capacitor 72, and a resistor 74 is

5 connected between a junction between the resistor 71 and the capacitor 72 and the output terminal of the operational amplifier 73, and the input terminal of the operational amplifier 73 is connected to the ground through a parallel circuit of a resistor 75 and a capacitor 76. In this instance, the amplitude-frequency response may be such that the cut-off frequency on the bass side is

10 200Hz and the cut-off frequency on the higher pitch side is 400Hz while the cut-off response on the bass side is equal to +12dB/Oct and the cut-off response on the higher pitch side is equal to -12dB/OCT, as shown in Fig. 14. Preferred values for the both cut-off frequencies are determined in the similar manner as the cut-off frequency of the high pass filter 32 and the cut-off

15 frequency of the low pass filter 33 have been chosen.

The amplitude-frequency of the high pass filter 32 may have a shoulder portion in its cut-off response raised in order to boost a corresponding region. For example, considering the amplitude-frequency response shown in Fig. 15, denoting the frequency at which a peak on the

20 shoulder of the cut-off response occurs by f_0 and the bandwidth ΔF where the amplitude is by 3dB lower than the peak value, divided by f_0 , by Q , it is possible to increase Q value to provide a sharp peak on the shoulder as shown in Fig. 15, to provide a gentle slope or to prevent a peak from occurring.

The abscissa in Fig. 15 represents a normalized frequency axis in which the

25 frequency f_0 where the peak occurs is defined as 1. For the high pass filter 32 shown in Fig. 7, Q is defined as follows:

$$Q = \frac{1}{\sqrt{\frac{R1}{R2} \cdot \frac{C1}{C2}} + \sqrt{\frac{R1}{R2} \cdot \frac{C2}{C1}}}$$

Accordingly, assuming that C1=C2 and R1=R2, for example, it follows that Q = 0.5. Assuming that C1=C2, the greater R2 is chosen relative to R1, the greater Q. In this manner, the shoulder on the cut-off response can be raised as desired. By boosting a component or components adjacent to the lowest frequency among the components corresponding to double overtone regions which are picked out in this manner, the bass tone boosting effect can be enhanced. Alternatively, the timbre can be adjusted by changing Q. In this respect, it is desirable that the resistance R1 and/or R2 can be adjusted by a user.

Similarly, a peak may be formed on the shoulder of the cut-off response of the low pass filter 33, thus providing a steep cut-off response. In the example shown in Fig. 7, Q of the low pass filter 33a is defined as follows:

$$Q = \frac{1}{\sqrt{\frac{R4}{R3} \cdot \frac{C4}{C3}} + \sqrt{\frac{R3}{R4} \cdot \frac{C4}{C3}}}$$

Accordingly, when a choice is made such that R3=R4, the greater C3 is chosen relative to C4, the greater Q, thus allowing the cut-off response to be made steep.

Distortion applying means 34 may comprise a clipper circuit formed by an anti-parallel connection of silicon diodes as shown in Fig. 2, a light emitting diode which exhibits a non-linear voltage-current response, or a circuit which uses a plurality of diodes or other semiconductor elements as switching elements to provide a non-linear response by a piecewise line

approximation. To effect the application of the distortion using a digital technology, non-linear responses may be stored in storage means to be subsequently read therefrom as mentioned previously, or a function which exhibits a non-linear response such as a polynomial or a power function may
5 be used to apply a distortion. Also, the high pass filter 32 and the low pass filter 33 shown in Figs. 5 and 7 may be connected in a reversed sequence from the illustration.

In the above description, the filter means 31 is used to pick out components corresponding to double overtone regions from a bass musical
10 instrument. However, it is also possible to pick out principally only components corresponding to double overtones of a musical instrument such as a base, for example, for which the bass tones are to be boosted. When principally picking out only components corresponding to the double overtones of the base, the filter means 31 may comprise a bandpass filter
15 shown in Fig. 13, which may be a narrow-bandpass filter having a cut-off frequency on the bass side and a cut-off frequency on the higher pitch side which coincide with each other. An example of the resulting amplitude-frequency response is shown in Fig. 16. In this Figure, the pass frequency is 200Hz, and a response is such that a peak is located at the location of 200Hz
20 with an attenuation on both the bass side and the higher pitch side which is equal to 12dB/OCT.

As mentioned previously, the filter means 31 may comprise the high pass filter 32 alone. However, in this instance, the distortion applying means 34 should be one having an input-output response which is non-linear and
25 which has no point symmetry with respect to the center of the amplitude of an input signal, for example, a response such as shown in Fig. 6, thus allowing an increased number of components corresponding to even-numbered

overtones to be produced to enable tones to be produced which are brilliant and clearly accentuated.

In either instance, the low pass filter 37 may not be used, but when it is used, the choice of the amplitude-frequency response should be made in the
5 similar manner as mentioned above.

In the above description, various parts have been principally constructed with analog circuits, but may be constructed with digital circuits. In this instance, where a digital output signal from a CD player, or a digital signal which is decoded from a musical data transmitted by electronic
10 distribution is used an audio signal to be input as a digital signal, the various parts shown in Fig. 5 may be constructed by digital circuits, and the digital audio signal may be input to the input terminal 11. Where an analog audio is input, the audio signal input to the input terminal 11 may be converted into a digital signal in an analog-digital converter 81 as indicated in broken lines in
15 Fig. 5 before feeding it to the filter means 31 and the summer 18. Also, a digital output signal from the summer 18 is converted into an analog signal in a digital-analog converter 82 to be delivered to the output terminal 15.

The present invention can be implemented by using a software processing. By way of example, as shown in Fig. 17, a CPU or DSP (digital
20 signal processor) 84, a program memory 85 and a non-linear memory 86 are connected to a bus 83, and where an audio signal from an input terminal 11 is an analog signal, it is converted into digital data in an A/D converter 81. Alternatively, digital data which is decoded from musical data that is transmitted by electronic distribution is directly downloaded into CPU 84
25 through the bus 83. CPU 84 reads, decodes and executes the program which is stored in the program memory 85. The decoding and execution of the program performs a processing operation as shown in Fig. 18, for example.

Specifically, the input audio data is initially downloaded (S1), a filter processing is applied to the downloaded audio data to pick out component data corresponding to double overtone regions of a bass musical instrument (S2), the pick-out operation being performed by applying a bandpass filter operation which is similar to that shown in Fig. 14 to the input audio data or by applying a high pass filter processing which is similar to that of the high pass filter 32 as shown in Fig. 5 to the input audio data (S2-1), and subsequently a first low pass filter processing similar to that of the low pass filter 33 is applied (S2-2). Either one of the high pass filter processing (S2-1) and the low pass filter processing (S2-2) may precede the other.

Subsequently, a distortion applying operation (S-3) takes place with respect to component data corresponding to double overtone regions which are picked out by the filter processing mentioned above. By way of example, the non-linear memory 86 shown in Fig. 17 stores non-linear input-output responses such as is shown in Fig. 6, for example. The non-linear memory 86 is read out in accordance with the component data corresponding to the double overtone region which is picked out to apply a non-linear distortion to the component data corresponding to this double overtone region.

Alternatively, a calculation of a non-linear function is made in the CPU 84 using the component data corresponding to the double overtone region as a variable to apply a non-linear distortion to the component data corresponding to the double overtone region. If required, a second low pass filter processing similar to that of the low pass filter 37 shown in Fig. 5 may be applied to the component data corresponding to the double overtone region to which the non-linear distortion is applied (S4), and the processed data may be added with the input audio data (S-5) and fed to the D/A converter 82 shown in Fig. 17 (S-6). D/A converter 82 converts the input data into an analog

signal and delivers it to the output terminal 15.

By way of example, the processing program shown in Fig. 18 may be installed in a memory within a personal computer; non-linear input-output response data may be stored; musical data may be received by electronic
5 distribution and decoded; and CPU in the personal computer may be caused to execute the loaded program with respect to the decoded digital data. Thus, CPU 84, the program memory 85 and the non-linear memory 86 shown in Fig. 17 may be disposed within the personal computer.

As described above, in accordance with the invention, the occurrence
10 of acoustic abnormalities of bass tones having an increased loudness which results from a cross modulation between the fundamental tone components of a plurality of the bass musical instruments is avoided, the likelihood that the alto and/or higher pitch region may be excessively boosted to a stronger degree than the bass due to the overtones which are based on the bass tones is
15 avoided, the loss of a time concurrency between the bass components and the higher pitch components is avoided, and the likelihood for the occurrence of acoustic abnormalities due to a cross modulation between musical tones from higher pitch musical instruments is avoided.

Distortion applying means allows even-numbered overtones to be
20 produced, allowing tones to be obtained which are clearly accentuated and brilliant.

WHAT IS CLAIMED IS:

1. An acoustic effect apparatus comprising
filter means for picking out components corresponding to the double overtone regions of a bass musical instrument such as a base or a bass drum from an audio signal which is input from an input terminal;
and distortion applying means receiving the components corresponding to the double overtone regions which are picked out by the filter means and applying a non-linear distortion to the components corresponding to the double overtone regions.
2. An acoustic effect apparatus according to Claim 1 in which the filter means has a cut-off response on the bass side which is gentle enough to allow a fundamental tone component of the bass musical instrument to be delivered even though subject to a level reduction.
3. An acoustic effect apparatus according to Claim 2 in which the cut-off response on the bass side of the filter means is chosen to be on the order of +12dB/OCT.
4. An acoustic effect apparatus according to Claim 1 in which the filter means has a cut-off response on the higher pitch side which is steeper than the cut-off response on the bass side.
5. An acoustic effect apparatus according to Claim 4 in which the cut-off response on the higher pitch side of the filter means is on the order of – 24dB/OCT or steeper.
6. An acoustic effect apparatus according to Claim 1 in which the filter means has a cut-off frequency on the bass side which is chosen in a range of 50~300Hz and has a cut-off frequency on the higher pitch side which is chosen to be in a range of 200~450Hz.
7. An acoustic effect apparatus according to Claim 6 in which the

filter means has a cut-off frequency on the bass side which is substantially equal to 200Hz and a cut-off frequency on the higher pitch side which is substantially equal to 400Hz.

8. An acoustic effect apparatus according to one of Claims 1 to 7 in which the filter means comprises a high pass filter having a cut-off frequency which is equal to the cut-off frequency on the bass side, and a low pass filter having a cut-off frequency which is equal to the cut-off frequency on the higher pitch side.

9. An acoustic effect apparatus according to Claim 8 in which the high pass filter has a small peak formed on a shoulder located adjacent to the cut-off frequency of its amplitude-frequency characteristic curve.

10. An acoustic effect device according to one of Claims 1 to 7 in which the filter means comprises a bandpass filter.

11. An acoustic effect device according to one of Claims 1 to 7, further comprising means for changing the cut-off frequency of the filter means.

12. An acoustic effect apparatus according to Claim 1 in which the distortion applying means has an input-output response which is a non-linear response which has no point symmetry with respect to the center of an input amplitude.

13. An acoustic effect apparatus according to Claim 12 in which the non-linear response is S-shaped with respect to a rectilinear line which represents a linear input-output response and is defined by a curve which has no point symmetry with respect to a reference point of an input and an output.

14. An acoustic effect apparatus according to Claim 13 in which the distortion applying means comprises a transistor having a collector, to which an output from the filter means is fed and an emitter which delivers an output

signal, and means for setting up a base current of the transistor, the distortion applying means utilizing a non-linear response occurring adjacent to zero point of the collector current-collector-emitter voltage response of the transistor.

15. An acoustic effect apparatus comprising
a narrow-bandpass filter for picking out a double overtone component of a desired fundamental tone of a bass musical instrument from an audio signal which is input from an input terminal;

and distortion applying means for receiving the double overtone component which is picked out by the narrow-bandpass filter for applying a non-linear distortion to the double overtone component.

16. An acoustic effect apparatus according to Claim 15 in which the narrow-bandpass filter has a cut-off response on the bass side which is chosen on the order of +12dB/OCT.

17. An acoustic effect apparatus according to Claim 15 in which the distortion applying means has an input-output response which is S-shaped with respect to a rectilinear line representing a linear response and which is defined by a curve having no point symmetry with respect to a reference point of an input and an output.

18. An acoustic effect apparatus comprising
a high pass filter for picking out a component corresponding a double or higher overtone of a bass musical instrument from an audio signal which is input from an input terminal;

and distortion applying means for receiving the component corresponding to the double or higher overtone which is picked out by the high pass filter and for applying a non-linear distortion to the component corresponding to the double or higher overtone;

the distortion applying means having an input-output response which is a non-linear response having no point symmetry with respect to the center of an input amplitude.

19. An acoustic effect apparatus according to Claim 18 in which the non-linear response is an input-output response which is S-shaped with respect to a rectilinear line representing a linear response and which is defined by a curve having no point symmetry with respect to a reference point of an input and an output.

20. An acoustic effect apparatus according to Claim 18 in which the high pass filter has a cut-off response which is substantially equal to +12dB/OCT and has a cut-off frequency of about 200Hz.

21. An acoustic effect apparatus according to Claim 18 in which the high pass filter has a small peak formed on a shoulder located adjacent to a cut-off frequency of its amplitude-frequency characteristic curve.

22. An acoustic effect apparatus according to one of Claims 1 to 7 and 12 to 21, further comprising a summer for summing an output signal from the distortion applying means and the input audio signal from the input terminal for delivery to an output terminal.

23. An acoustic effect apparatus according to Claim 22, further comprising a low pass filter which is fed with an output signal from the distortion applying means and which provides a gentle attenuation of components substantially equal to or greater than 200Hz before feeding the summer.

24. An acoustic effect method comprising
a step of picking out a component corresponding to a double overtone region of a bass musical instrument such as a base or a bass drum from an input audio signal from an input terminal by means of filter means;

and a step of applying a non-linear distortion to the component corresponding to the double overtone region which is picked out by means of distortion applying means.

25. An acoustic effect method according to Claim 24, further comprising a step of summing the double overtone region component to which the non-linear distortion is applied and the input audio signal together for delivery.

26. An acoustic effect method according to Claim 24 or 25 in which the filter means has a cut-off frequency on the bass side which is substantially equal to 200Hz and has a cut-off response which is substantially equal to +12dB/OCT, a cut-off frequency on the higher pitch side which is substantially equal to 400Hz and a cut-off response which is steeper than substantially -24dB/OCT.

27. An acoustic effect method according to Claim 26 in which the distortion applying means has an input-output response which is a non-linear response having no point symmetry with respect to the center of an input amplitude.

28. A recorded medium having a program recorded thereon for execution by a computer of an acoustic effect apparatus, the program including

a processing for downloading audio data;

a filter processing for picking out a component data corresponding to double overtone region of a bass musical instrument such as a base or a bass drum from the downloaded audio data;

and a distortion applying processing which applies a non-linear distortion to the component data corresponding to the double overtone region which is picked out.

29. A recorded medium according to Claim 28 in which the filter processing is a processing with a cut-off response at +12dB/OCT at a cut-off frequency on the bass side which is anywhere in a range of 50~300Hz and with a cut-off response at -24dB/OCT or steeper at a cut-off frequency on the higher pitch side which is anywhere in a range of 200~450Hz.

30. A recorded medium according to Claim 29 in which the filter processing has a cut-off frequency on the bass side which is substantially equal to 200Hz and a cut-off frequency on the higher pitch side which is substantially equal to 400Hz.

31. A recorded medium according to one of Claims 28 to 30 in which the filter processing comprises a high pass filter processing with a cut-off frequency and a cut-off response on the bass side and a low pass filter processing with a cut-off frequency and a cut-off response on the higher pitch side.

32. A recorded medium according to Claim 28 in which the distortion applying processing is a processing having an input-output response which is a non-linear response having no point symmetry with respect to the center of an input amplitude.

33. A recorded medium according to one of Claims 28, 29 and 32 in which the distortion applying processing is a processing in which a reference is made to a table having non-linear input-output responses recorded therein in terms of the component data corresponding to the double overtone region which is picked out to deliver output data.

34. A recorded medium according to one of Claims 28, 29 and 32 in which the distortion applying processing is a processing which calculates a non-linear function using a variable defined by the component data corresponding to the double overtone region which is picked out to deliver

output data.

35. A recorded medium according to one of Claims 28, 29 and 32 in which the program includes a program which causes the computer to execute a low pass filter processing which causes the level to be gradually reduced for the component data corresponding to the double overtone region to which the non-linear distortion is added as the component data goes toward the higher pitch.

ABSTRACT OF THE DISCLOSURE

A high pass filter 32 having a cut-off frequency of 200Hz and a cut-off response of +12dB/OCT and a low pass filter 33 having a cut-off frequency of 400Hz and a cut-off response steeper than -24dB/OCT are used to pick out components in a double overtone region of 200~400Hz of a bass musical instrument such as a base or a bass drum from an input audio signal. The component which is picked out is input to distortion applying means 34 having an input-output response which is a non-linear response having no point symmetry with respect to 0 point, thus applying a distortion to cause even-numbered overtone components to be produced. An output from the distortion applying means 34 and the input audio signal are summed in a summer 18 to be delivered. Natural tones which have boosted bass tones and which are free from impurity are obtained.

FIG. 1

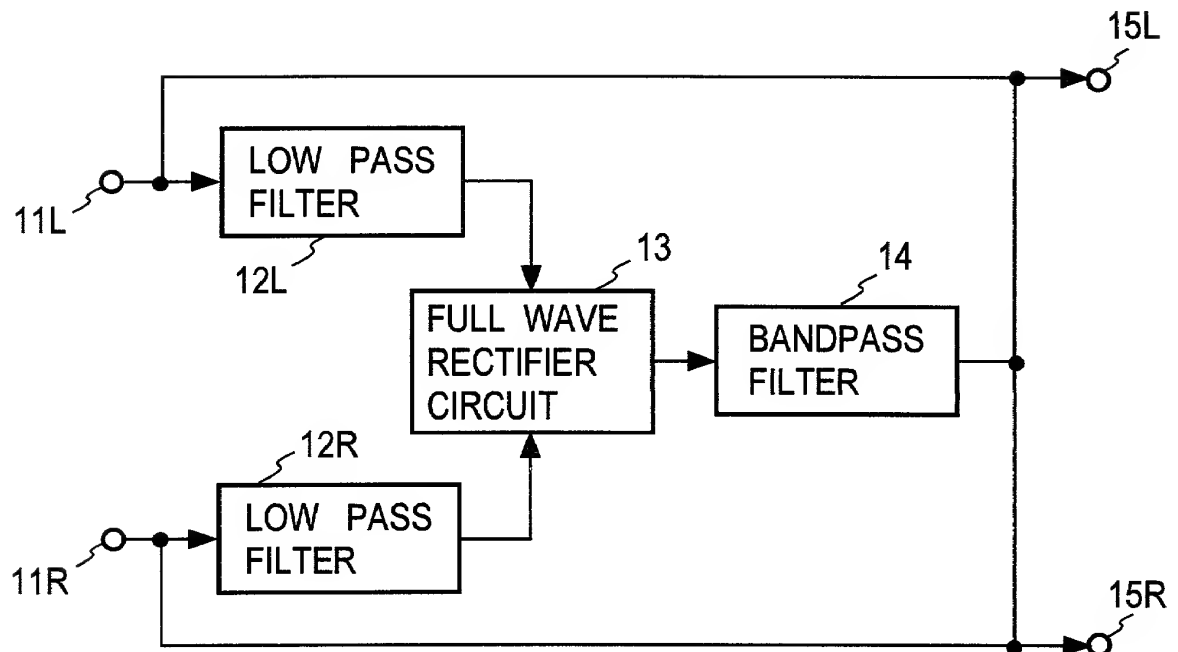
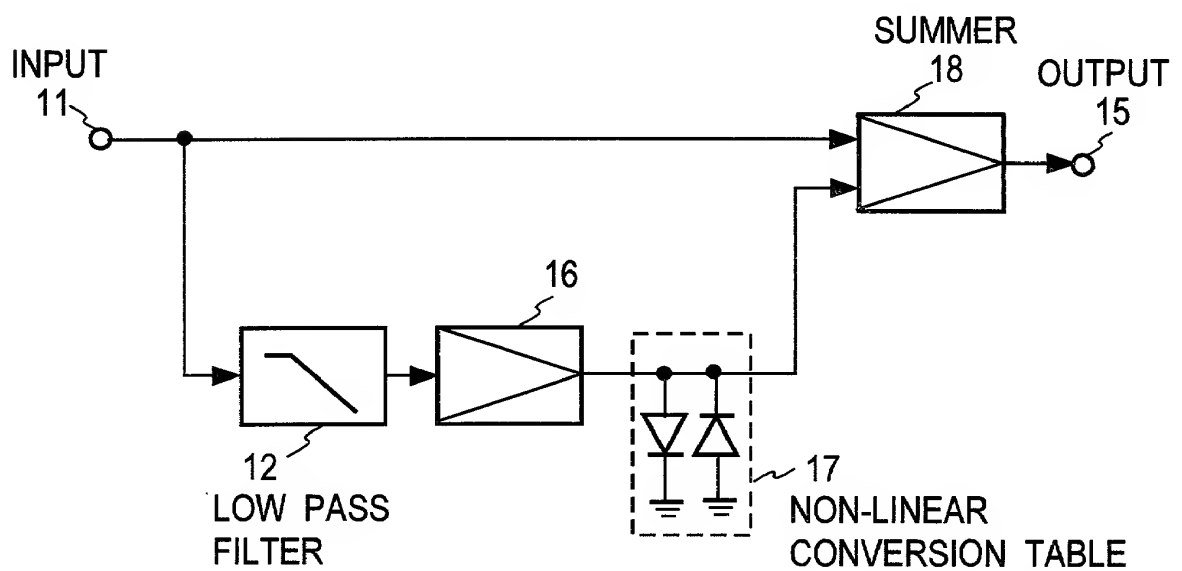


FIG. 2



F/G. 3

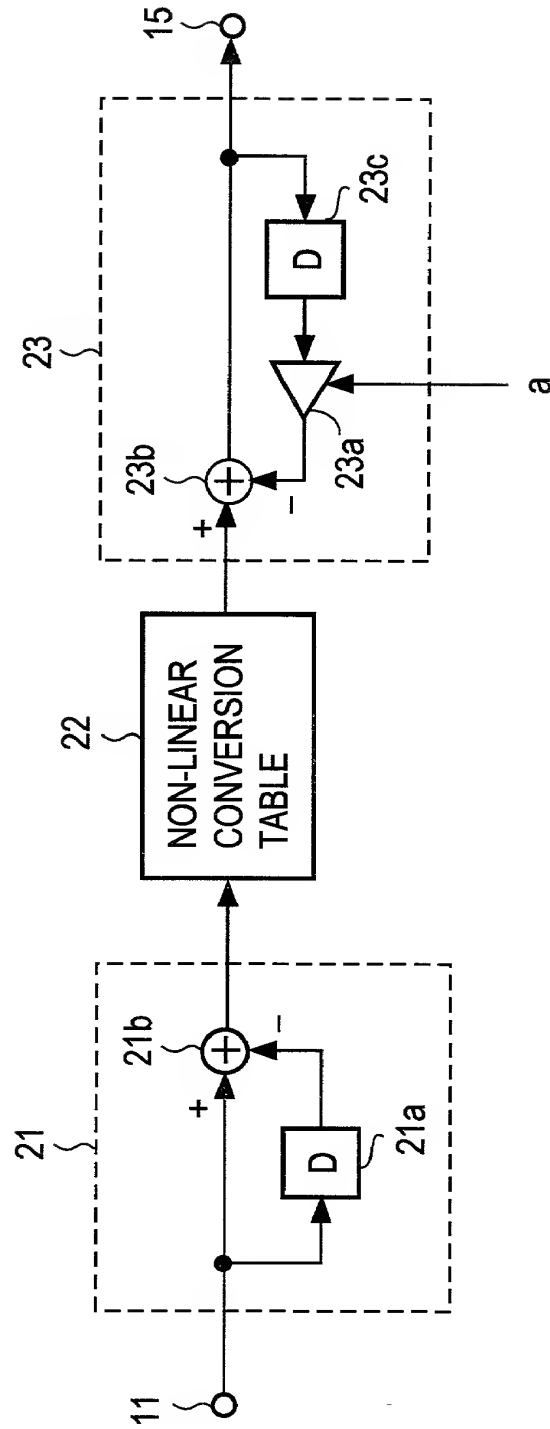


FIG. 4A

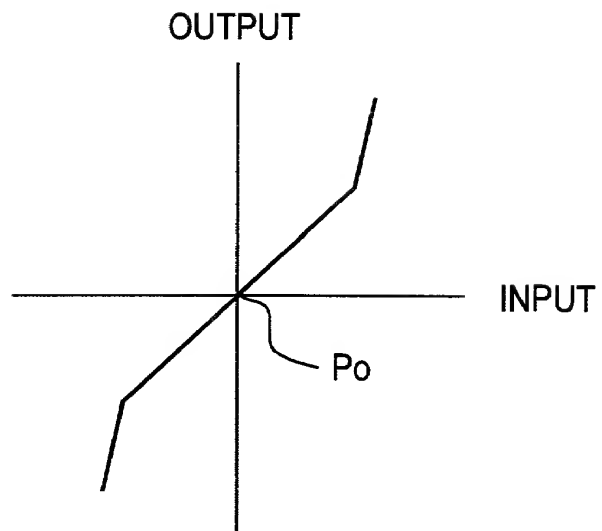


FIG. 4B

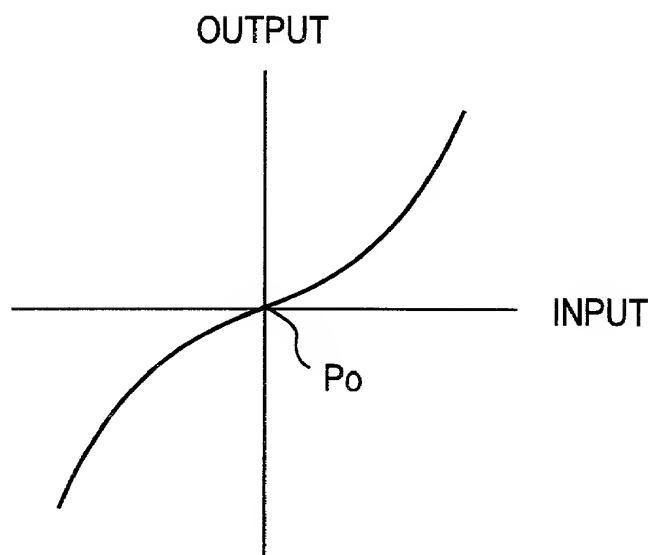
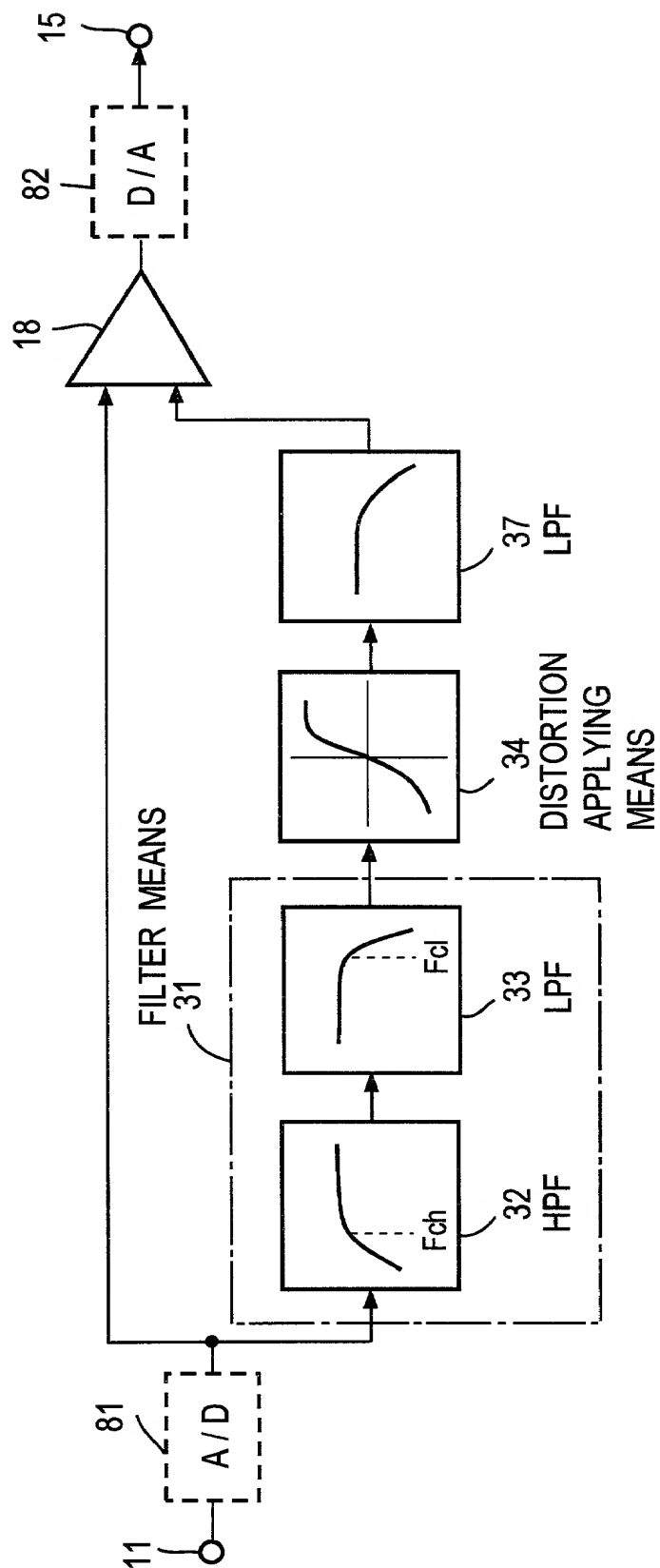


FIG. 5



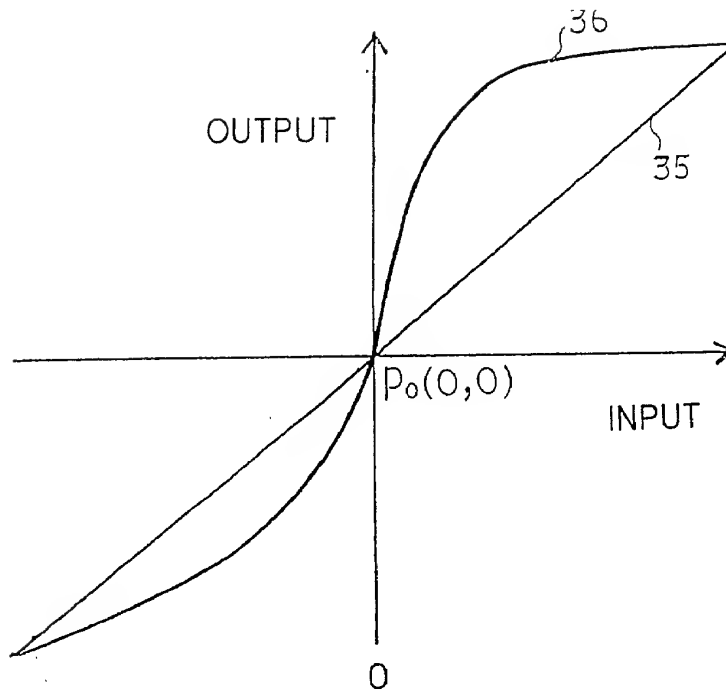


FIG. 6

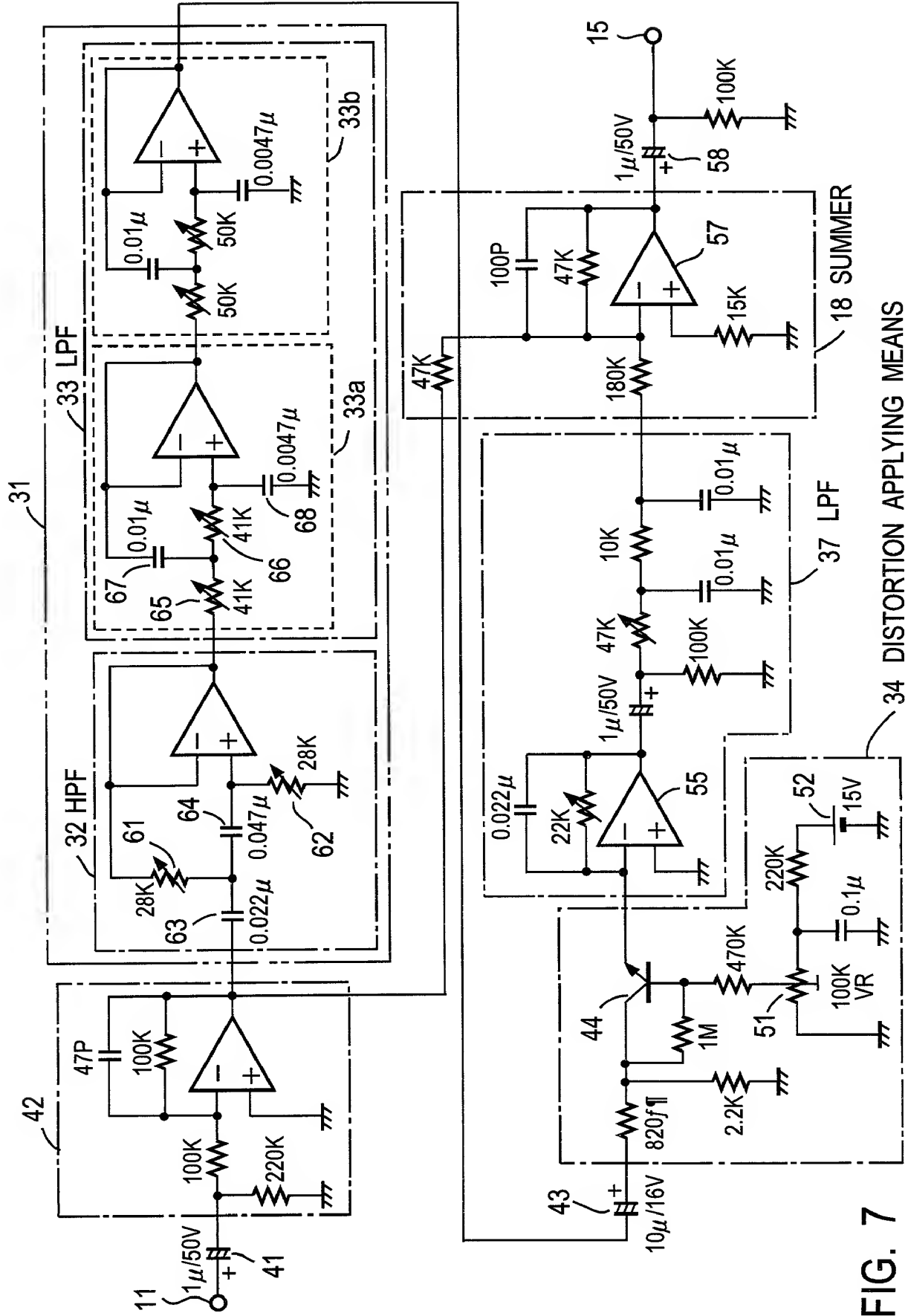
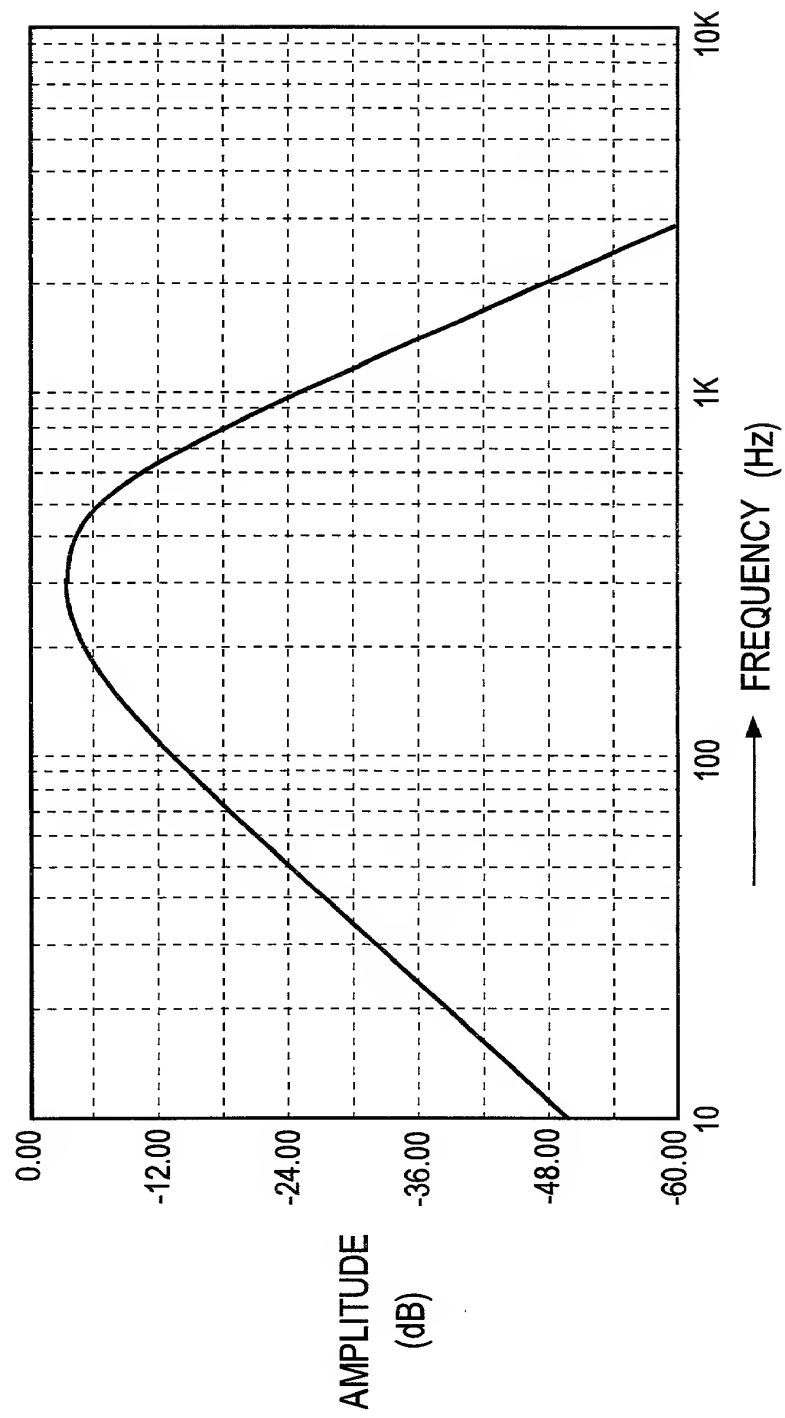


FIG. 7

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	



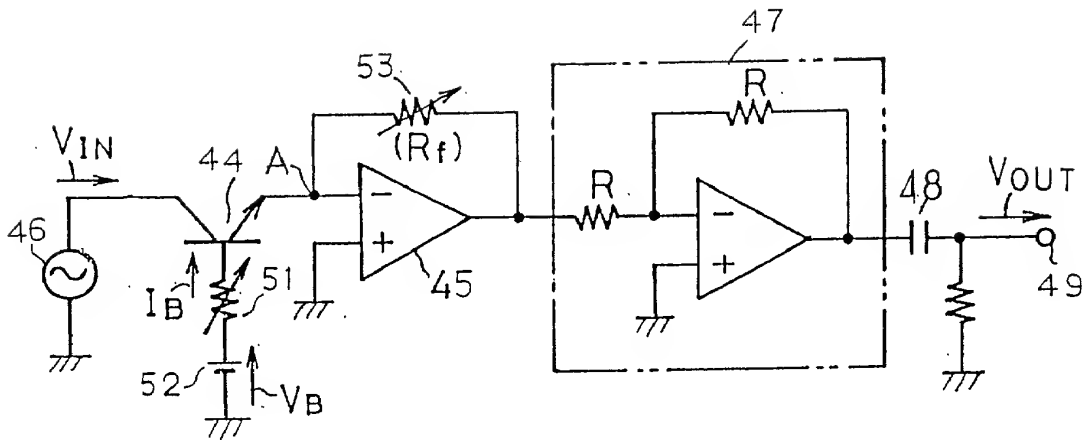


FIG. 9

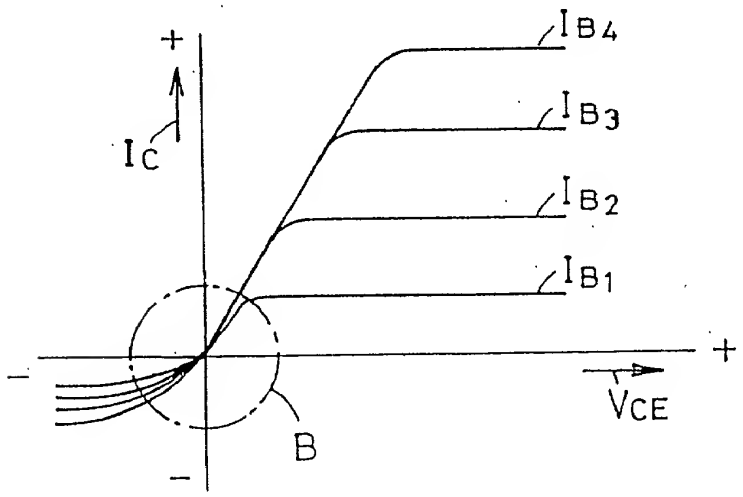


FIG. 10

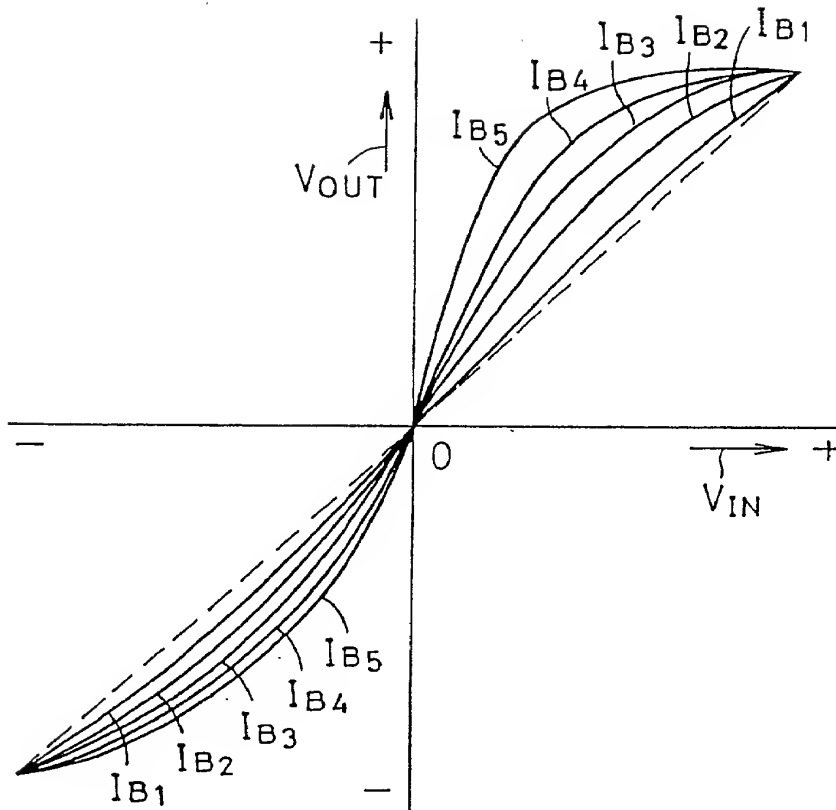


FIG. 11

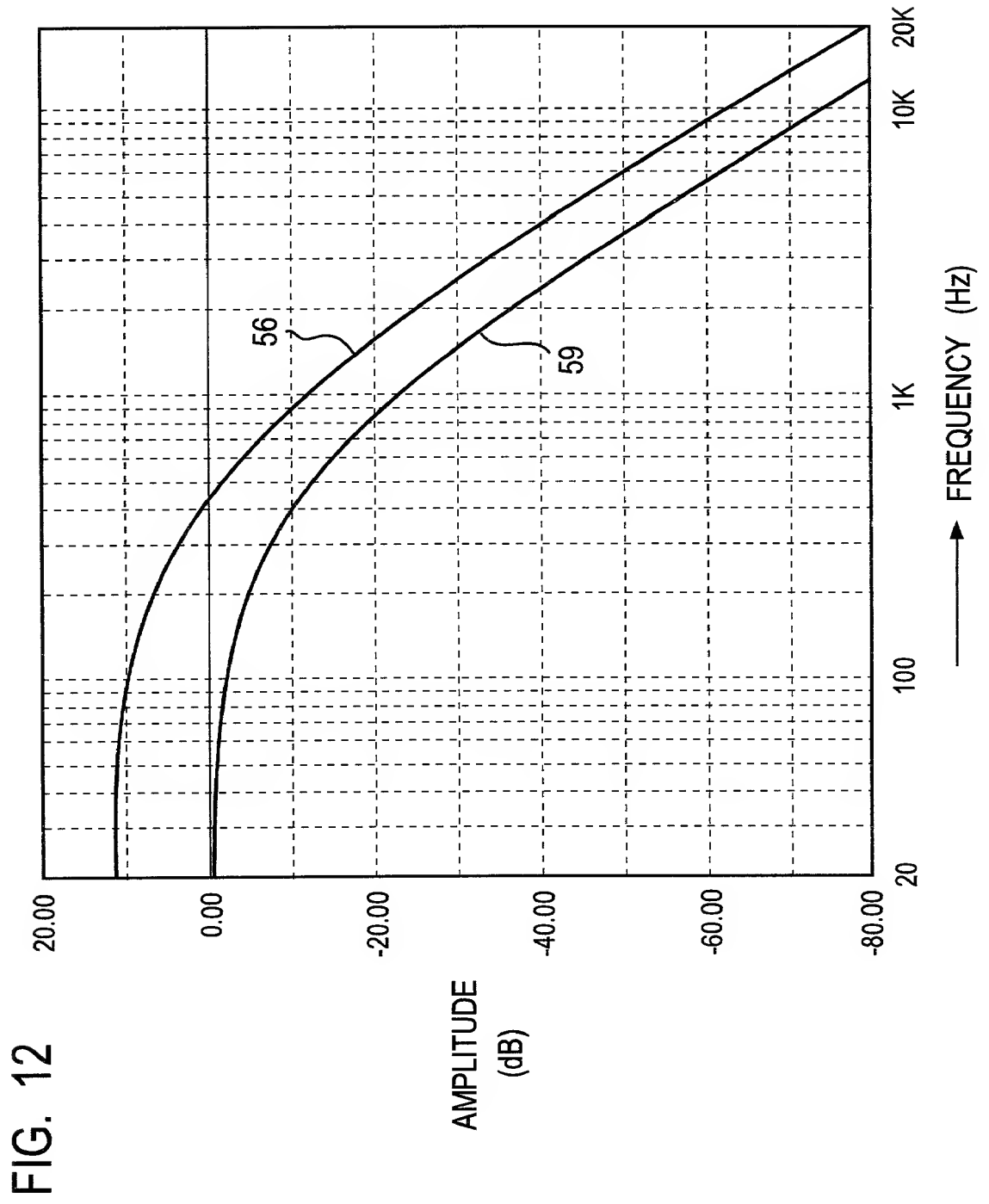


FIG. 13

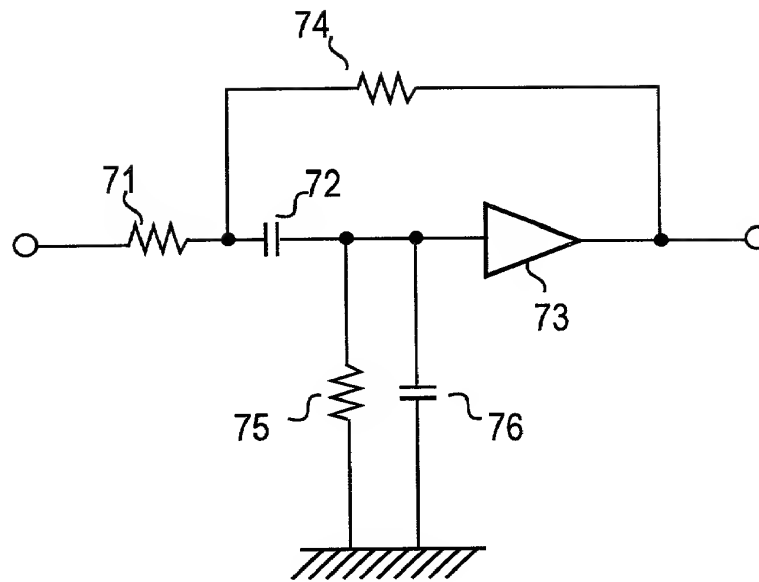


FIG. 14

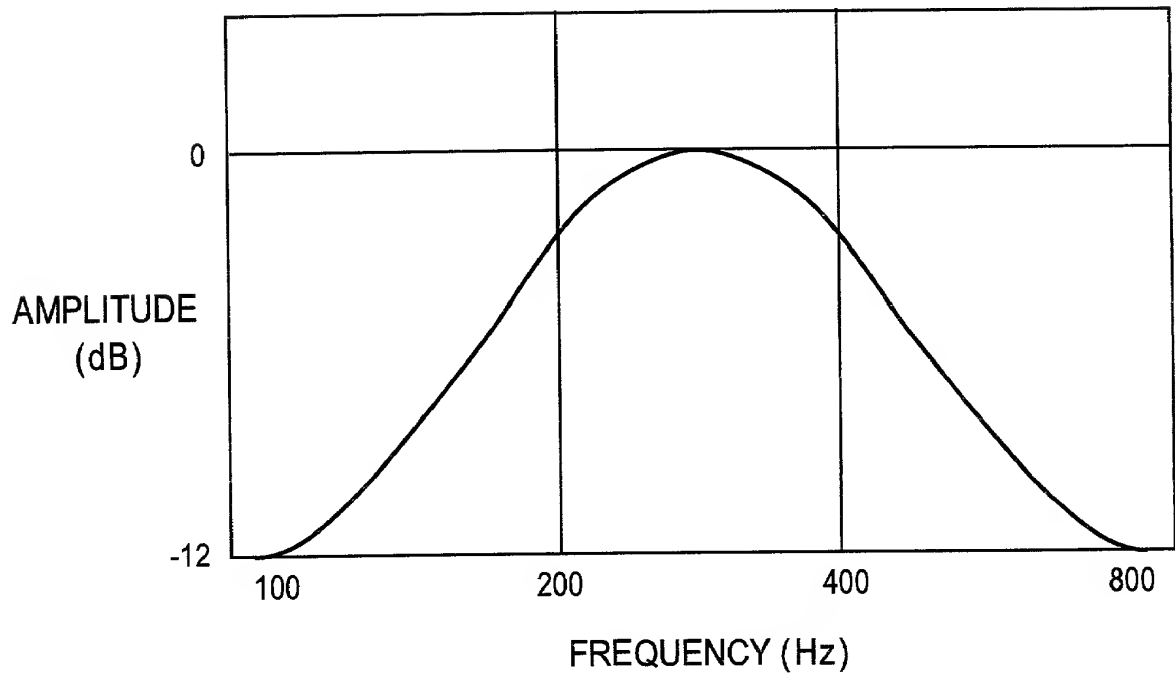


FIG. 15

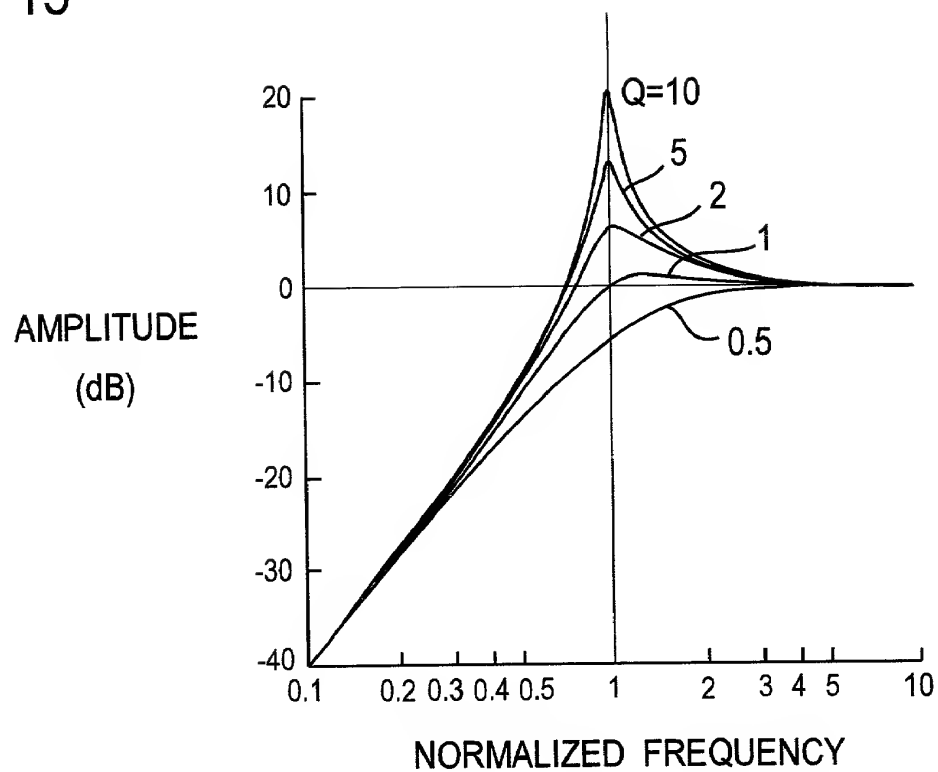


FIG. 16

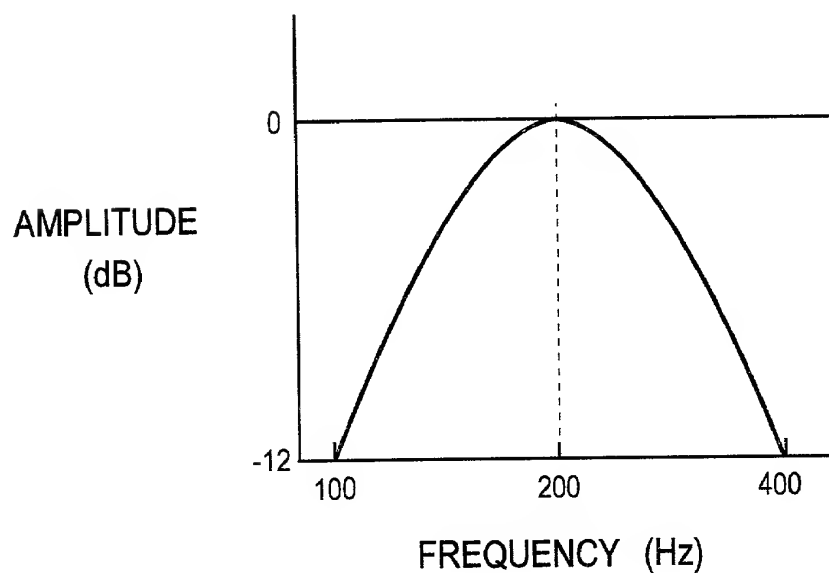


FIG. 17

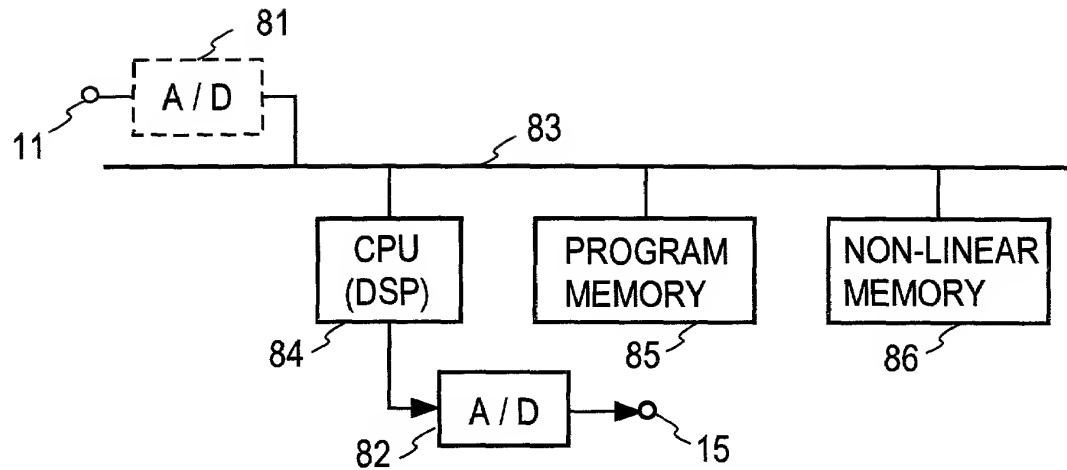
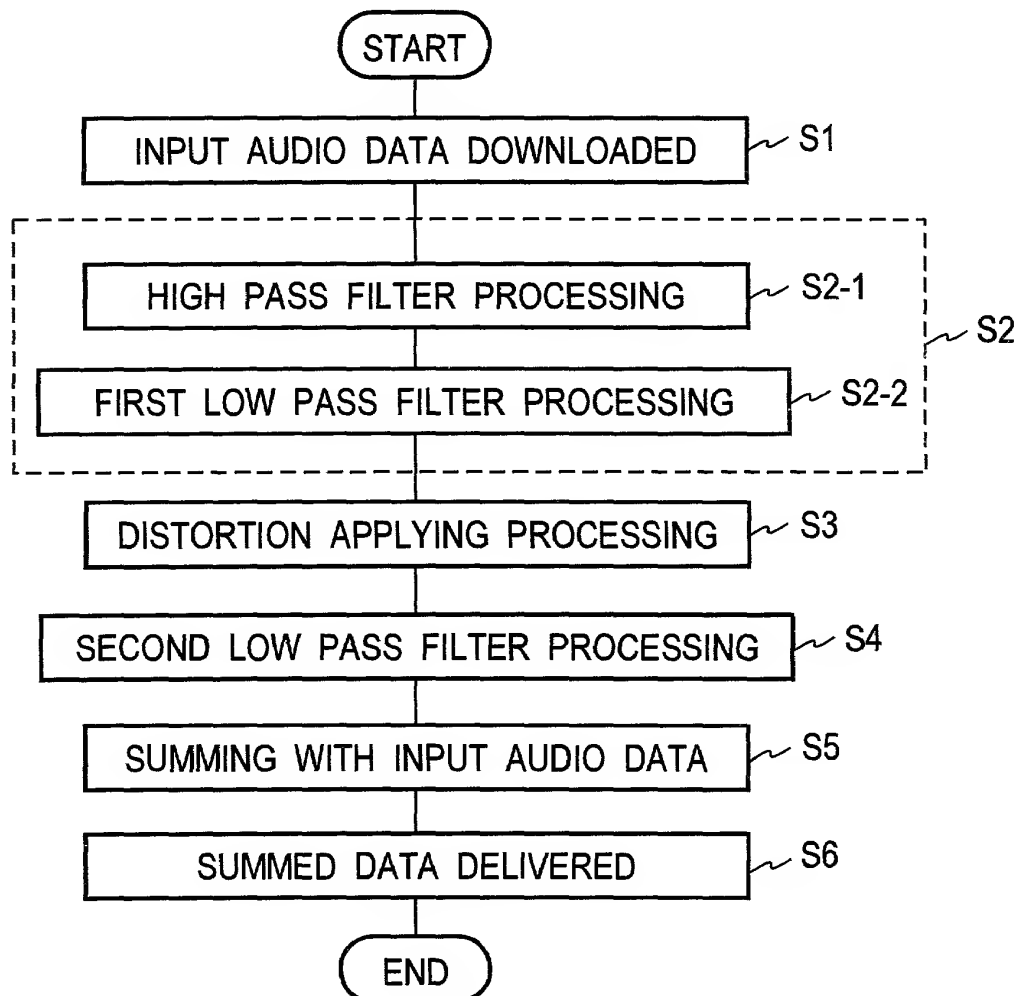


FIG. 18



11705405

DECLARATION FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **"ACOUSTIC EFFECT APPARATUS AND METHOD AND PROGRAM RECORDED MEDIUM THEREFOR"**
the specification of which: (check one)

[XX] is attached hereto. ☒ was filed on 21/12/1999 as United States Patent Application Serial No. or PCT International Application Number PCT/JP99/07180 and was amended on 19 (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 CFR § 1.56(a).

Prior Foreign Application(s). I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate listed below, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Application No.	Country	Day/Month/Year Filed	Priority Claimed
<u>366374/98</u>	<u>Japan</u>	<u>24/12/98</u>	<input checked="" type="checkbox"/> []
(Application No.)	(Country)	(Day/Month/Year Filed)	Yes No
<u> </u>	<u> </u>	<u> </u>	[] []
(Application No.)	(Country)	(Day/Month/Year Filed)	Yes No
<u> </u>	<u> </u>	<u> </u>	[] []
(Application No.)	(Country)	(Day/Month/Year Filed)	Yes No

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

Application No.	Filing Date
<u> </u>	<u> </u>
<u> </u>	<u> </u>

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by 35 U.S.C. § 112, first paragraph, I acknowledge the duty to disclose material information as defined in 37 CFR § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(U.S. Application Serial No.)	(U.S. Filing Date)	(Status--patented, pending, abandoned)
<u> </u>	<u> </u>	<u> </u>
(U.S. Application Serial No.)	(U.S. Filing Date)	(Status--patented, pending, abandoned)

I hereby appoint George Vande Sande, Registration No. 17,276; Burton A. Amernick, Registration No. 24,852; Stanley B. Green, Registration No. 24,351; Richard Wiener, Registration No. 18,741; Townsend M. Belser, Jr., Registration No. 22,956; Morris Liss, Registration No. 24,510; Martin Abramson, Registration No. 25,787; George R. Pettit, Registration No. 27,369; Elzbieta Chlopecka, Registration No. 32,767; Eric J. Franklin, Registration No. 37,134; Jeffri A. Kaminski, Reg. No. 42,709; and William E. Curry, Registration No. P43,572, my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Send Correspondence and Direct Telephone Calls to:
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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☒ See next page for additional inventors

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DECLARATION FOR PATENT APPLICATION

Page Two

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Inventor's Signature _____ Date _____
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Full name of fifth joint inventor (if any): _____
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Full name of sixth joint inventor (if any): _____
Inventor's Signature _____ Date _____
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Full name of seventh joint inventor (if any): _____
Inventor's Signature _____ Date _____
Residence Address _____
Citizenship _____
Post Office Address _____

Full name of eighth joint inventor (if any): _____
Inventor's Signature _____ Date _____
Residence Address _____
Citizenship _____
Post Office Address _____